CLAIMS

(marked-up version of claim amendments)

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1. (CURRENTLY AMENDED) A method of providing synchronized ventilatory support to a patient comprising the steps of:

providing apparatus to deliver ventilatory support to a patient, the apparatus comprising an airflow sensor and a respiratory effort sensor;

determining ~~the patient's~~ at least one instantaneous phase of respiration ~~phase~~ of the patient at least in part from both measured respiratory airflow and a signal from a respiratory effort sensor,

calculating a desired pressure value using the determined phase and a desired ventilation pressure amplitude; and

delivering ventilation to said patient in accordance with said desired pressure value.

2. (CURRENTLY AMENDED) The method of claim ~~1~~ 47 wherein said respiratory effort sensor is selected from a group of effort sensors that are independent of a leak in airflow that may affect respiratory airflow measurement including:

(a) a suprasternal notch sensor;

(b) an esophageal pressure effort sensor; and

(c) an electromyograph.

3. (PREVIOUSLY AMENDED) The method of claim 41 wherein the phase determining step comprises evaluating fuzzy inference rules relating to said signal from said respiratory effort sensor.

4. (ORIGINAL) The method of claim 3 wherein said phase determining step further comprises evaluating fuzzy inference rules relating to the rate of change of said signal from said respiratory effort sensor.

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5. (ORIGINAL) The method of claim 4 wherein said phase determining step further includes the sub-step of evaluating fuzzy logic inference rules relating to the measured respiratory airflow.

6. (ORIGINAL) The method of claim 5 wherein said phase determining step further includes the sub-step of evaluating fuzzy logic inference rules relating to the rate of change of the measured respiratory airflow.

7. (ORIGINAL) The method of claim 1 wherein said phase determining step further includes the sub-step of evaluating fuzzy logic inference rules relating to the measured respiratory airflow.

8. (ORIGINAL) The method of claim 7 wherein said phase determining step further includes the sub-step of evaluating fuzzy logic inference rules relating to the rate of change of the measured respiratory airflow.

9. (PREVIOUSLY AMENDED) The method of claim 1 wherein the desired ventilation pressure amplitude is varied between a non-zero minimum value and a maximum value.

10. (ORIGINAL) The method of claim 9 wherein said step of calculating a desired pressure value includes deriving an error value that is a function of the difference between calculated patient ventilation and a target value.

11. (PREVIOUSLY AMENDED) The method of claim 4 wherein said fuzzy inference rules include at least one rule selected from a group of rules including:

(a) If the effort signal is zero and increasing fast, then phase is about 0 revolutions;

Cont'd (b) If the effort signal is medium and increasing moderately, then phase is about 0.2 revolutions;

(c) If the effort signal is large and decreasing fast, then phase is about 0.5 revolutions; and

(d) If the effort signal is medium and decreasing moderately, then phase is about 0.7 revolutions.

12. (ORIGINAL) The method of claim 4 wherein said fuzzy inference rules include a rule in which the start of inspiration is associated with approximately zero respiratory effort which is increasing fast.

13. (ORIGINAL) The method of claim 4 wherein said fuzzy inference rules include a rule in which mid-inspiration is associated with medium respiratory effort which is increasing moderately.

14. (ORIGINAL) The method of claim 4 wherein said fuzzy inference rules include a rule in which the beginning of expiration is associated with large respiratory effort which is decreasing fast.

15. (ORIGINAL) The method of claim 4 wherein said fuzzy inference rules include a rule in which mid-expiration is associated with medium respiratory effort which is decreasing moderately.

16. (PREVIOUSLY AMENDED) The method of claim 6 wherein said fuzzy inference rules include at least one rule selected from a group of rules including:

(a) If the airflow is zero and increasing fast, then phase is about 0 revolutions;

(b) If the airflow is large positive and steady, then phase is about 0.25 revolutions;

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(c) If the airflow is zero and falling fast, then phase is about 0.5 revolutions;

(d) If the airflow is large negative and steady, then phase is about 0.75 revolutions;

(e) If the airflow is zero and steady and the 5-second low-pass filtered absolute value of the respiratory airflow is large, then phase is about 0.9 revolutions;

(f) If the airflow is positive and the phase is expiratory, then phase is about 0.1 revolutions;

(g) If the airflow is negative and the phase is inspiratory, then phase is about 0.6 revolutions;

(h) If the 5-second low-pass filtered absolute value of the respiratory airflow is small, then phase in the respiratory cycle is increasing at a fixed rate equal to the patient's expected respiratory rate; and

(i) If the 5-second low-pass filtered absolute value of the respiratory airflow is large, then the phase in the respiratory cycle is increasing at a steady rate equal to the existing rate of change of phase, low-pass filtered with a time constant of 20 seconds.

17. (CURRENTLY AMENDED) An apparatus for providing synchronized ventilatory support to a patient comprising:

at least one sensor to generate a respiratory effort signal;

at least one sensor to generate a respiratory airflow signal;

a processor in communication with the effort signal and the airflow signal configured for analyzing both the respiratory airflow signal and the effort signal and to determine at least one instantaneous ~~respiratory~~ phase of a respiratory cycle of the patient and to generate a pressure request signal as a function of said instantaneous respiratory phase and a ventilation pressure amplitude; and

a servo-controlled blower to provide pressurized air to said patient in accordance with said pressure request signal.

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18. (PREVIOUSLY AMENDED) The apparatus of claim 42 wherein said at least one sensor is an effort sensor from a group of effort sensors that are independent of a leak in airflow that may affect respiratory airflow measurement including:

(a) a suprasternal notch sensor;

(b) an esophageal pressure effort sensor; and

(c) an electromyograph.

19. (CURRENTLY AMENDED) The apparatus of claim 17 wherein said processor is configured to control an evaluation of~~es~~ fuzzy inference rules relating to said respiratory effort signal.

20. (CURRENTLY AMENDED) The apparatus of claim 18 wherein said processor is further configured to control an evaluation of~~es~~ fuzzy inference rules relating to the rate of change of said respiratory effort signal.

21. (CURRENTLY AMENDED) The apparatus of claim 20 wherein said processor is further configured to control an evaluation of~~es~~ fuzzy logic inference rules relating to the respiratory airflow.

22. (CURRENTLY AMENDED) The apparatus of claim 21 wherein said processor is further configured to control an evaluation of~~es~~ fuzzy logic inference rules relating to the rate of change of the respiratory airflow.

23. (CURRENTLY AMENDED) The apparatus of claim 17 wherein said processor is further configured to control an evaluation of~~es~~ fuzzy logic inference rules relating to the respiratory airflow.

24. (CURRENTLY AMENDED) The apparatus of claim 23 wherein said processor is further configured to control an evaluation of~~es~~ fuzzy logic inference rules relating to the rate of change of the respiratory airflow.

25. (PREVIOUSLY AMENDED) The apparatus of claim 17 wherein the ventilation pressure amplitude is varied between a non-zero minimum value and a maximum value.

26. (PREVIOUSLY AMENDED) The apparatus of claim 25 wherein the generation of said pressure request signal includes deriving an error value that is a function of the difference between calculated patient ventilation and a target value.

27. (PREVIOUSLY AMENDED) The apparatus of claim 20 wherein said fuzzy inference rules include at least one rule selected from a group of rules including:

(a) If the effort signal is zero and increasing fast, then phase is about 0 revolutions;

(b) If the effort signal is medium and increasing moderately, then phase is about 0.2 revolutions;

(c) If the effort signal is large and decreasing fast, then phase is about 0.5 revolutions; and

(d) If the effort signal is medium and decreasing moderately, then phase is about 0.7 revolutions.

28. (ORIGINAL) The apparatus of claim 20 wherein said fuzzy inference rules include a rule in which the start of inspiration is associated with approximately zero respiratory effort which is increasing fast.

29. (ORIGINAL) The apparatus of claim 20 wherein said fuzzy inference rules include a rule in which mid-inspiration is associated with medium respiratory effort which is increasing moderately.

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30. (ORIGINAL) The apparatus of claim 20 wherein said fuzzy inference rules include a rule in which the beginning of expiration is associated with large respiratory effort which is decreasing fast.

31. (ORIGINAL) The apparatus of claim 20 wherein said fuzzy inference rules include a rule in which mid-expiration is associated with medium respiratory effort which is decreasing moderately.

32. (PREVIOUSLY AMENDED) The apparatus of claim 22 wherein said fuzzy inference rules include at least one rule selected form a group of rules including:

(a) If the airflow is zero and increasing fast, then phase is about 0 revolutions;

(b) If the airflow is large positive and steady, then phase is about 0.25 revolutions;

(c) If the airflow is zero and falling fast, then phase is about 0.5 revolutions;

(d) If the airflow is large negative and steady, then phase is about 0.75 revolutions;

(e) If the airflow is zero and steady and the 5-second low-pass filtered absolute value of the respiratory airflow is large, then phase is about 0.9 revolutions;

(f) If the airflow is positive and the phase is expiratory, then phase is about 0.1 revolutions;

(g) If the airflow is negative and the phase is inspiratory, then phase is about 0.6 revolutions;

(h) If the 5-second low-pass filtered absolute value of the respiratory airflow is small, then phase in the respiratory cycle is increasing at a fixed rate equal to the patient's expected respiratory rate; and

(i) If the 5-second low-pass filtered absolute value of the respiratory airflow is large, then phase in the respiratory cycle is increasing at a steady rate equal to the existing rate of change of phase, low-pass filtered with a time constant of 20 seconds.

c1 33. (CURRENTLY AMENDED) A method of providing synchronized ventilatory support to a patient comprising the steps of:

providing apparatus for ventilatory support to a patient comprising a flow sensor and a respiratory effort sensor;

determining at least one~~the patient's~~ instantaneous phase of respiration of the patient ~~phase~~ represented as a fraction of a revolution of a respiratory cycle at least in part from a signal from the respiratory effort sensor and a signal from the flow sensor,

calculating a pressure value using the determined phase and a ventilation pressure amplitude; and

delivering ventilation to said patient in accordance with said pressure value.

34. (CURRENTLY AMENDED) The method of claim ~~33~~ 48 wherein said respiratory effort sensor is selected from a group of effort sensors that are independent of a leak in airflow that may affect respiratory airflow measurement including:

(a) a suprasternal notch sensor;

(b) an esophageal pressure effort sensor; and

(c) an electromyograph.

35. (ORIGINAL) The method of claim 34 wherein said phase determining step comprises evaluating fuzzy inference rules relating to said signal from said respiratory effort sensor.

36. (ORIGINAL) The method of claim 35 wherein said phase determining step further comprises evaluating fuzzy logic inference rules relating to the rate of change of said signal from said respiratory effort sensor.

C1 cont'd 37. (CURRENTLY AMENDED) An apparatus for providing synchronized ventilatory support to a patient comprising:

at least one sensor to generate a respiratory effort signal;

at least one sensor to generate a respiratory airflow signal;

a processor in communication with the effort signal and airflow signal configured for analyzing both said effort signal and said airflow signal and to determine instantaneous ~~respiratory~~ phase of a respiratory cycle of the patient represented as a fraction of a revolution of a respiratory cycle and to generate a desired pressure request signal as a function of said instantaneous respiratory phase and a desired ventilation pressure value; and

a servo-controlled blower to provide pressurized air to said patient in accordance with said pressure request signal.

38. (PREVIOUSLY AMENDED) The apparatus of claim 37 wherein said at least one sensor is an effort sensor from a group of effort sensors that are independent of a leak in airflow that may affect respiratory airflow measurement including:

(a) a suprasternal notch sensor;

(b) an esophageal pressure effort sensor; and

(c) an electromyograph.

39. (CURRENTLY AMENDED) The apparatus of claim 38 wherein said processor is further configured to control an evaluation of~~es~~ fuzzy inference rules relating to said respiratory effort signal.

40. (CURRENTLY AMENDED) The apparatus of claim 39 wherein said processor is further configured to control an evaluation of~~es~~ fuzzy inference rules relating to the rate of change of said respiratory effort signal.

41. (CURRENTLY AMENDED) The method of claim 2 wherein the instantaneous ~~respiration~~ phase is a fraction of a revolution of a respiration cycle.

42. (CURRENTLY AMENDED) The apparatus of claim 17 wherein the instantaneous ~~respiratory~~ phase is a fraction of a revolution of a respiratory cycle.

43. (NEW) The method of claim 2 wherein the apparatus to deliver ventilatory support to a patient includes a mask.

44. (NEW) The apparatus of claim 17 further comprising a mask and conduit through which said pressurized air is delivered to the patient.

45. (NEW) The method of claim 33 wherein the apparatus for ventilatory support further comprising a mask.

46. (NEW) The apparatus of claim 37 further comprising a mask and conduit through which said pressurized air is delivered to a patient.

47. (NEW) The method of claim 1 further comprising the step of positioning the effort sensor to sense patient effort external to the patient-ventilator airway circuit in a manner that is independent from leak in the patient-ventilator airway circuit.

48. (NEW) The method of claim 33 further comprising the step of locating the respiratory effort sensor to detect respiratory effort in a manner that renders an effort signal from the respiratory effort sensor independent of leak in the patient-ventilator airway circuit of the apparatus for ventilatory support.